SHORT- DURATION GASDYNAMIC DEVICES FOR INDUSTRIAL APPLICATIONS

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1. Introduction

During 30 years in the Institute of Theoretical and Applied Mechanics of the Siberian Branch of the Russian Academy of Sciences different pneumatic devices were developed and used for aerospace industry. These devices can produce an air flow with desired level of parameters within a small time lag (less than 0.1 seconds). The short creation time greatly reduces the complexity and cost of the device and allows one to reach extreme parameters of the flow, which are impossible to obtain in similar devices of the stationary action. For example, in pulsed mode it is very easy to get an air flow rate equal to tens and even hundreds of kilograms per second, what is possible only by means of ultra high power compressor installations. The power of air compressed within standard gas-container with a volume of 40 dm^3 can reach 1.5 MJ, that allows, at a prompt ejection, creation of a high-energy and high-power air jet (with the capacity of 15 MW) for a short period of time. This is a main reason that pneumatic pulse devices could be of great interest for different industrial application. In particular, new effective technologies for a peelings of industrial and domestic equipment could be developed. All pneumatic methods of a peelings are based on the short influence of the powerful air jet, which is created with the help of special pneumopulse generator [1-3]. It can be noted that a very short amounts of pneumatic generator designs (5 or 10 items) could give possibility for a large number of pneumopulse technologies development.

2. Advantages of pneumopulse technologies

Main economic practicability of pneumopulse technologies application consists in removal labour-consuming expensive and dangerous manual operations a peelings, whereupon becomes a possible transition to the real preventive cleaning and increases efficiency of constantly working equipment.

Pneumatic pulse technologies are characterized:

- high reliability and safety of using in consequence of simplicities of designs;
- elementary manual or easy automatic control;
- an absence of the dangerous influence on cleaned surfaces in consequence of small duration of the pulse;
- wide range of the intensity regulation;
- absence of dust emergence because of the small amount of exhausted air;
- low cost of the equipment fabrication and montage;
- safety of usage in explosive terms, for instance, in coal bunkers.

3. Pneumopulse technologies description

Some of pneumopulse technologies have been designed at the ITAM and tested in practice are described below as an example.

3.1. Pneumopulse cleaning of pipelines. The technology is intended for cleaning of inner surfaces of pipelines with diameter from 50 mm to 300 mm from saline, carbonate, calcareous, coal, cement, concrete and other solid deposits. It based on the short shock-wave interaction of the pulse air jets with inner surface of the pipe (see Fig. 1). Pulse air jets are created by means of small sizes pneumatic generator of original design [4].

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Abstract

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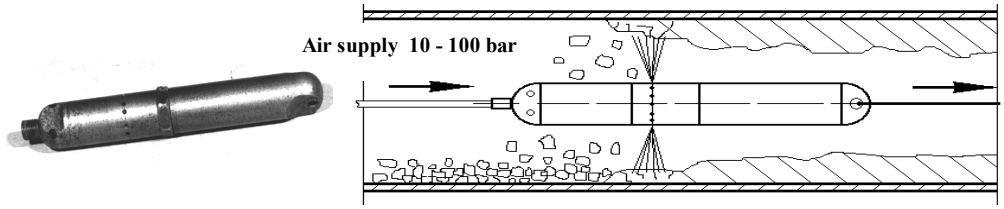

Fig. 1. Scheme of pipeline cleaning.

The technique of peelings includes the following procedure:

- preparation of the particular section of pipeline with the length from 50 to 200 m depending on local possibilities;
- pull of the working pneumatic pulse device through the cleaned pipeline. The device is filled with pressurized air during the movement and ejects this air in form of high-power pulse jets in hundredths second, which brings deposition layer destroying;
- removal of destroyed deposit pieces.

Average productivity of the cleaning procedure ranges up to 1 m per minute. The technology has very small air consumption, it is pollution-free and harmless for environment.

3.2. Pneumopulse cleaning of the bunkers. This technology is designed for removal of bridging and sticking of granular materials on the walls inside bunkers and other sorts of large volumes for loose material keeping. It based on the short shock-wave interaction of the pulse air jets with loose material and inner walls of the volume. Pulse air jets are created by means of system which consists of some pneumatic generators, located in different points. A number of pneumopulse generators in the cleaning system and their location on a bunker walls depends on a given problem, on granular material characteristics, on bunker design peculiarities, etc. An ordinary quantity of generators for one bunker ranges from 2 to 8 units. When the cleaning system is working each of pulse generators is filled during 10 or 20 seconds with compressed air from an ordinary compressor installation. After that it promptly ejects high-energy air jet which creates a strong influence on the treated material (see Fig. 2).

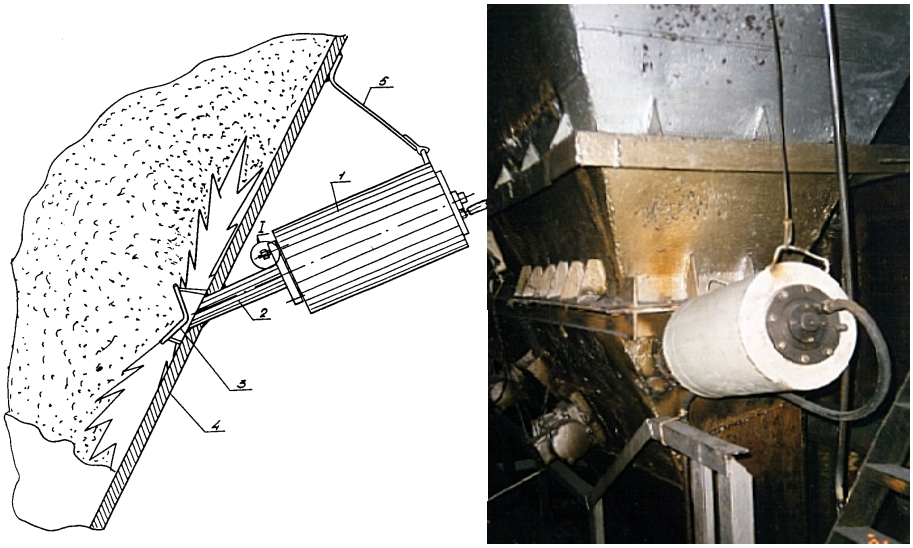

Fig. 2. Pneumatic pulse device mounted on the bunker wall
1 – pneumatic pulse device; 2 – tube; 3 – deflector; 4 – bunker wall; 5 – support.

Pneumopulse cleaning system for loose materials allow:

- to use the volume more efficiently;
- to decrease a number of bunkers in technological process;
- to eliminate the necessity of intensive and dangerous manual labor when bunker cleaning;
- high level of safety in operation due to simplicity of design;
- a wide range of intensity adjustment, which allows solving of different tasks;
- elementary manual or automatic control;
- possibility of exploitation in explosive-hazardous conditions;
- absence of dust formation due to small amount of ejected air;
- absence of dangerous impact on the bunker walls due to short duration of air pulse.

3.3. Pneumopulse cleaning of heat exchangers. Different kinds of heat exchangers are extensively used in technological processes connected with heat power transmission. Here the cooled liquid flows through the heat exchanger pipes, and the cooling liquid is in the inter-pipe space. As a rule, a technical water with an excess content of rigidity salts is used as a heat carrier, that results in scurf layer formation with low level of heat transfer index and in decreasing of heat exchange effectiveness. For example, when a pipeline scurf layer is as thick as 0.2 mm, the temperature head is halved. Traditional means of pipelines cleaning (mechanical, chemical, ultrasonic, etc) are labour intensive and low effective. The problem can be solved by means of pneumopulse technology of cleaning, which involves a shock-wave impact on the pipeline surfaces. A special middle-size pneumatic pulse device was developed for this problem solving. This pneumatic generator collects some portion of compressed air and then ejects high-power air jet into the volume of heat exchanger. While entering into the heat exchanger which is filled with water, the airflow generates a shock wave, which propagates through the liquid and destroys the scurf. The number of air supply points, their orientation and duration of the cleaning procedure are defined experimentally depending on the heat exchanger configuration and strength characteristics of deposit.

Suggested technology was successfully used for cleaning of interior and exterior pipe surfaces of more than 30 heat exchangers of different types. For instance, 9 nozzles (with diameter of 20 mm) were used and welded to the heat exchanger 800 TNG housing for to destroy a scurf

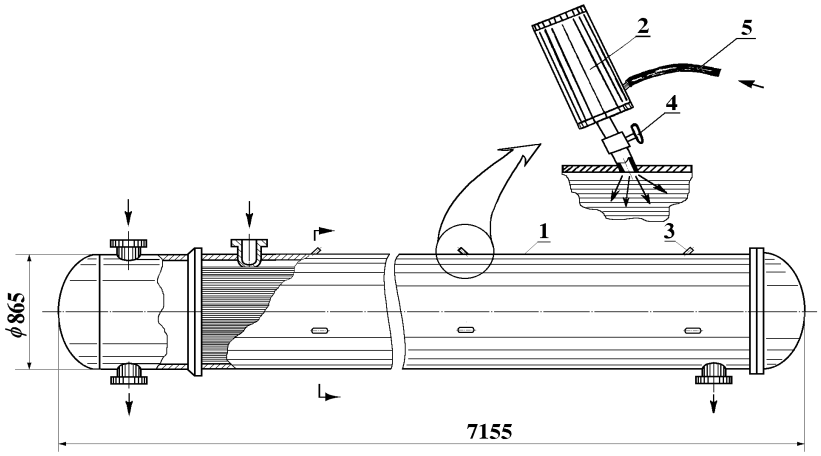

Fig. 3. Heat exchanger 800 TNG.
1 –- housing; 2 – pnevmatic pulse device; 3 – tube; 4 – valve; 5 – air supply.

layer with thickness from 2 to 5 mm at the inter-pipe space (see Fig.3). It was produced from 120 to 150 shots of the pulse generator with storage volume of 1 dm^3 and initial pressure up to 20 bars through each nozzle.

3.4. Pneumopulse system for cleaning of convective surfaces of the high-power boiler. Ash deposit incipient when coal and black oil combustion on heating surfaces of boilers, considerably reduce the power of the boiler and duration of its between-repairs period. Therefore development of efficient peeling systems is a real technological problem.

The activities on examination of pneumopulse device capabilities for peeling of boiler surfaces were initiated in ITAM since 1992 with help of regional program "Siberia". The laboratory testing of pneumopulse action on models of deposit with different strength have shown strong influence of non-stationary shock waves on process of deposit fracture rather than by effect of a jet flow of gas. It was established, that the efficiency of peeling action is appreciably determined by orientation of a shock wave concerning a sample. It was offered to use multi-jet device, which essentially reduce ash wear-out of peeling tubes and can increase the peeling surface in 1,5 times with the same air flow rate [6]. As a result of the conducted examinations the new pneumopulse system of cleaning (SPC-1) was designed.

The pneumopulse system SPC-1 is intended for preventive cleaning of tube packages of boiler from ash deposit in a band of temperatures less than 700 C. An operational mode of the device is long-lived work with intervals of actuation in accordance with the technological schedule of peeling. The device has a manual activation by the boiler operator in a determined intervals of time. The estimation of results of activity and adjustment of operational mode of a system is executed by the boiler operator.

The basis of this system is fast-response pneumopulse generators, which allow to create a strong air flow with shock waves (see Fig.4). The considerable increase of peeling efficiency is reached by organization of simultaneous activity of impulse generators. The working process of system SPC-1 is fully automatic, and air, as working agent, makes this system completely safe for inventory and operational staff.

The known methods of peeling differ from an offered system for the following reasons:

- deep sliding devices of a type OG on a vapour - impossibility in most cases accommodation on requirements of layout, high cost of the installation and operation;

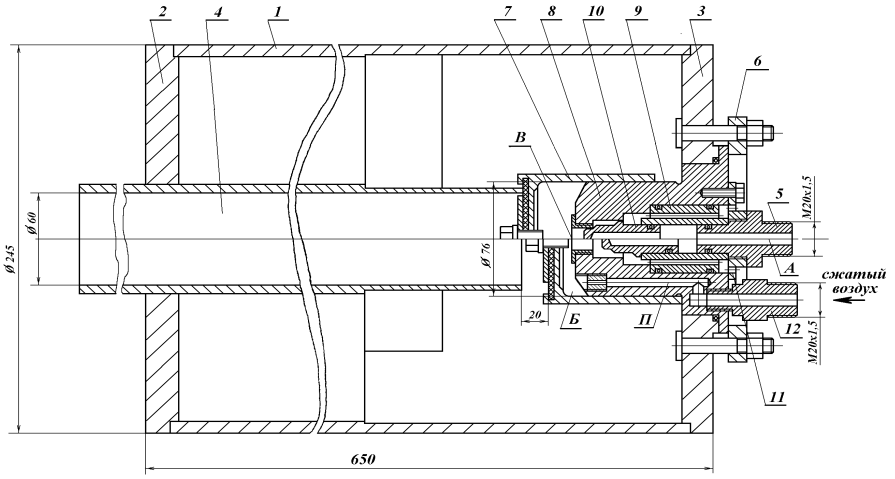

Fig. 4. Sketch of pneumopulse generator PG – 25/40.
1 – prechamber; 2 – flange; 3 – exhaust tube; 5 – control tube; 6 – flange; 7 – close valve; 8 – body; 9 – insert; 10 – control valve; 11 – cover; 12 – input tube.

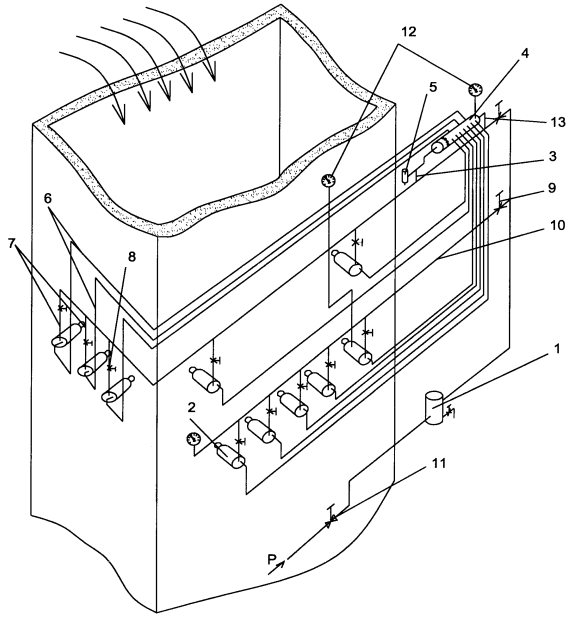

Fig. 5. Pneumopulse system for cleaning of convective surfaces of the high-power boiler BKZ – 320
1 – oil and water separator; 2 – pneumopulse generators PG – 25/40; 3,6,7,10,13 – air pipelines; 4 – control collector; 5 – electromagnetic valve; 8, 9, 11 – valves; 12 – electrocontact manometers.

- gas fuel combustion devices - danger of use, difficulties with automation and layout of a great many of chambers;
- generators of shock waves with powder charges - impossibility of automation, organizational difficulties at use of powder charges;
- pneumopulse devices of the previous design - impossibility of formation of a shock wave because of low response speed of valves.

The given system SPC-1 was designed, manufactured and installed on the boiler BKZ-320 of Novosibirsk power station No. 3. The peeling system is entered with 20 pneumopulse generators of type PG-25/40 [5], which serve for energy storage of compressed air and periodic shootting with pulsing jets on dirty surfaces of convective heat exchanger of the boiler. The general view of a pulse generator PG-25/40 is exhibited on Fig. 4. Sheme of arrangement of a system SPC-1 on the boiler aggregate is shown in the Fig. 5. Air with pressure 5 - 6 bar is supplied from a shop network to the pneumopulse devices and into a control collector. In the chosen moment the control collector by command from the control panel provides one-time prompt drop of air pressure in control tubes of pneumopulse generators, that calls their operation. Simultaneous sharp surge of air happens from pneumogenerators, which acts on the cleaning surfaces. The cycle of cleaning can consist of one or several shots. Optimum quantity of shots in a cycle and interval between cycles is established in a fitting time depending on operational mode of the boiler.

The actual trials of an installed system were initiated at the end of 2001. The first obtained results display acceptable reliability and efficiency of peeling even at low levels of pressure of working gas (5 bar). Now acceptance trials of a system are carried out.[6]. The surveyed pneumopulse system of peeling SPC-1 is constructed on modern advancement in the field of non-stationary gas dynamics and with performances that has no analogs in the world. After successful completion of trials the similar systems can be recommended for duplication on power stations of Russia and abroad.

REFERENCES

1. **Zvegintsev V.I.** Patent RF No 2023228, 1992.
2. **Zvegintsev V.I.** Patent RF No 2113287, 1996.
3. **Chirkashenko V.F.** Patent RF No 2124952, 1997.
4. **Zvegintsev V. I., Paikova M. A.** Numerical and experimental investigation of the pulse jet device for pipelines cleaning. // Intern. Conf. on the Methods of Aerophys. Research: Proc. Pt III**.** Novosibirsk, 2000. P.173-177.
5. **Zvegintsev V. I.** Pneumopulse generator PG - 25/40. Technical description and operation instructions. Novosibirsk: ITAM, 2001.
6. **Zvegintsev V. I., Chirkashenko V.F., Timofeev M.V.** Pneumopulse system for cleaning of convective surfaces of the high-power boiler BKZ – 320: Report of ITAM, №1/2002, Novosibirsk, 2002.